Chromium-substituted hematite powder as a catalytic material for photochemical and electrochemical water oxidation

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**Fig. S1** XPS spectra of (A) Fe 2p and (B) Cr 2p in Fe$_{2}$O$_{3}$, Fe$_{1.6}$Cr$_{0.4}$O$_{3}$, Fe$_{0.7}$Cr$_{1.3}$O$_{3}$ and Cr$_{2}$O$_{3}$.

**Fig. S2** XPS spectra of (A) Fe 2p and (B) Cr 2p in Fe$_{1.6}$Cr$_{0.4}$O$_{3}$ before and after photochemical water oxidation.

**Fig. S3** UV-visible diffuse reflectance spectra and absorbance spectrum of Fe$_{2-x}$Cr$_{x}$O$_{3}$ and [Ru(bpy)$_{3}$]SO$_{4}$ (in aqueous phosphate solution, 100 mM, pH 7.5).
**Fig. S4** UV-vis absorbance spectra of the reactant solution after 50 min at +1.80 V (vs. RHE) electrolysis using Fe$_{2-x}$Cr$_x$O$_3$/FTO. Reaction condition is the same as Fig. 4. Black line is under similar condition but with 3–3.5 wt% H$_2$O$_2$ as a reductant.

**Fig. S5** Current-voltage curves for Fe$_{2-x}$Cr$_x$O$_3$ electrodes in a phosphate buffer solution. Scan rate, 20 mV s$^{-1}$; Solution, phosphate aqueous solution (100 mM pH 7.5) containing 3–3.5 wt% of H$_2$O$_2$.  

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Electronic Supplementary Information
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**Fig. S6** Impedance spectra of Fe\(_{2-x}\)Cr\(_x\)O\(_3\) electrodes in a phosphate buffer solution recorded at +1.40 V in dark or under visible light irradiation (480 < \(\lambda\) < 500 nm). Solution, phosphate aqueous solution (100 mM pH 7.5) containing 3–3.5 wt% of H\(_2\)O\(_2\). Charge transfer resistance values after curve fitting are also shown.

**Fig. S7** Impedance spectra of Fe\(_{2-x}\)Cr\(_x\)O\(_3\) electrodes in a phosphate buffer solution recorded at +1.80 V. Solution, phosphate aqueous solution (100 mM pH 7.5) without H\(_2\)O\(_2\).